Journal of Safety Research 41 (2010) 197–202

Contents lists available at ScienceDirect

Journal of Safety Research

journal homepage: www.elsevier.com/locate/jsr

Prioritizing prevention opportunities in the Washington State construction industry, 2003-2007

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ARTICLE INFO

Available online 14 April 2010

Keywords:
Construction industry
Workers' compensation
Injury prevention
Claims cost
Severity

ABSTRACT

Objective: This study compares construction industry groups in Washington State by injury severity and cost, and ranks industry groups according to potential for prevention. *Methods:* All Washington State workers' compensation compensable claims with date of injury between 2003 and 2007 were classified into North American Industrial Classification System (NAICS) industry groups. Claims were then aggregated by injury type and industry groups were ranked according to a prevention index (PI). The PI is the average of the rank orders of the claim count and the claim incidence rate. A lower PI indicates a higher need for prevention activities. The severity rate was calculated as the number of days of time loss per 10,000 full-time equivalents (FTEs). *Results:* For all injury types, construction industry groups occupy 7 of the top 15 PI ranks in Washington State. The severity rate among construction industry groups was twice that for non-construction groups for all injury types. Foundation, structure, and building exterior contractors (NAICS 2381) ranked highest in prevention potential and severity among construction industry groups for most common injury types including falls from elevation, fall on same level, struck by/against, and musculo-skeletal disorders of the neck, back, and upper extremity (WMSDs). Median claim costs by injury type were generally higher among construction industry groups. *Conclusions:* The construction industry in Washington State has a high severity rate and potential for prevention. The methods used for characterizing these industry groups can be adapted for comparison within and between other industries and states. *Impact on Industry:* These data can be used by industry groups and employers to identify higher cost and higher severity injury types. Knowledge about the relative frequencies and costs associated with different injury types will help employers and construction industry associations make better informed decisions about where prevention efforts are most needed and may have the greatest impact. The results of this study can also be used by industry stakeholders to cooperatively focus on high cost and high severity injuries and explore best practices, interventions, and solutions as demonstrated by efforts to prevent musculoskeletal disorders in masonry (Entzel, Albers, & Welch, 2007). Initiating construction industry groups to focus on high cost and high severity injuries may also help prevent other types of injuries.

1. Introduction

Work-related injuries and illnesses occur at relatively high rates and severity in the construction industry. According to the Bureau of Labor Statistics (BLS), the construction industry experienced an incidence rate of 540 total recordable injuries and illnesses and 190 cases with days away from work per 10,000 workers in 2007 (BLS, 2008). Injury claims in the construction industry have been well documented as being longer in duration (Cheadle et al., 1994; Horwitz & McCall, 2004) and more costly (Horwitz & McCall; Waehrer, Dong, Miller, Haile, & Men, 2007) than claims in other industries. Similarly, workers' compensation claims data have documented higher costs and more time loss due to construction-related injuries when compared with estimates based on BLS data (Dement & Lipscomb, 1999). The BLS Supplementary Data System was analyzed and it was determined that construction laborers consistently rank high on lists of occupations that contribute to diseases (Leigh & Miller, 1998). It has also been demonstrated that assessment of the cost and severity of injuries and illness in the construction industry is likely under-estimated (Glazner et al., 1998). These data are valuable to construction industry groups and employers and can be utilized to identify higher cost and higher severity injury types. The objective of this study was to compare construction industry groups and assign rankings by common injury types using indicators incorporating frequency and cost of claims and severity measured by time loss.

2. Materials and Methods

Washington State law mandates employers to provide workers' compensation insurance for all employees. Workers in Washington

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doi:10.1016/j.jsr.2010.02.010

State, except federal government workers, are insured by an exclusive State Fund (SF) operated by the Washington State Department of Labor & Industries (L&I). Employers also have the option to self-insure if they meet the eligibility requirements. All SF workers' compensation claims associated data are maintained by L&I. According to hours reported to L&I by construction employers from 2003-2007, approximately 140,000 full-time equivalents (FTEs) were insured through the Washington State Fund while 8,000 FTEs (5.4% of total FTEs reported) were self-insured. Therefore, the use of State Fund insured compensable claims represents a large percentage of worker injury and illness from construction employers, and will be concentrated among employers not large enough to self insure in Washington State. Compensable workers' compensation claims are defined as injuries and illnesses that involve more than 3 days of lost work time, a partial or total permanent disability award claim, a worker kept on salary through the course of recuperation, or an injury or illness that results in a fatality.

Washington State workers' compensation data for compensable claims were used to characterize and prioritize injuries within and across construction industry groups in Washington State from 2003 to 2007. Injuries were characterized and prioritized using costs paid from workers' compensation insurance, the severity associated with injuries, and the potential for prevention. The construction industry was determined using employer accounts assigned a North American Industry Classification System (NAICS) code within the construction sector (NAICS, 2002). Analysis was conducted at the NAICS 4-digit level determining the 10 NAICS construction industry groups that were used in this analysis and are ranked among all other industry groups in Table 1.

All State Fund compensable workers' compensation claims in the construction industry with an injury date between January 1, 2003 and December 31, 2007 were identified and extracted from the L&I database on October 1, 2009. Associated claim information included ANSI Z16.2 codes for injury nature, type, body part, and source and all claim costs for wage replacement, medical bills, disability payments, and time loss days. Employer reported hours worked were used to determine FTEs. All compensable claims have an ANSI Z16.2 code to describe the injury or illness of the worker. These claim codes are also based on information reported on the workers' compensation claim form including physician diagnosis, medical findings, and injury narrative from the worker. State Fund insured claims costs for open claims are assessed at the time of data extraction and include an estimate by L&I for future expenses. State Fund claims provide accurate data on time loss days and only include days of time loss paid at the time of data extraction. Time loss is initially paid after 3 days of lost work time following the day of injury. If more than 14 days of time loss occurs, the first three days get wage replacement.

Employers' accounts were assigned a NAICS industry group classification based on the industry group in which the majority of claims occurred. Insurance premiums are based on the number of hours worked by employees as reported by the employer on a quarterly basis.

Data analysis included only State Fund compensable claims. Claims were grouped into distinct categories according to ANSI Z16.2 injury or illness type and were aggregated at the ANSI two digit code levels in order to identify common and high cost injuries and illnesses. The resulting aggregate categories were “abraded,” “bodily reaction,” “caught in, under, between,” “contact with electrical current,” “contact with temperature extremes,” “contact with radiation, caustics, toxics, and noxious substances,” “explosions,” “fall from elevation,” “fall on same level,” “non-traumatic neck, upper-musculoskeletal, and back,” “overexertion,” “gunshot,” “musculoskeletal disorders of the lower extremity,” “struck by/against,” “vehicular,” and “other” (Bonauto, Silverstein, Adams, & Foley, 2006). The “other” category includes claims with insufficient data or claims that were unclassifiable or different from the injury mode of other injuries in the category.

Washington workers' compensation data were used previously to identify work-related musculoskeletal disorder claims and costs (Silverstein, Welp, Nelson, & Kalat, 1998). For this data set, non-traumatic work-related musculoskeletal disorders of the neck, back, and upper extremity (WMSD) and lower extremity musculoskeletal disorders (LE-MSD) were defined and used as injury types. These musculoskeletal disorders types were defined using a combination of ANSI Z16.2 injury nature, injury type, and body part codes. The definition of WMSDs in this study was further refined by the use of a physician diagnosis.

Full-time equivalent (FTE) employees were defined as working 2,000 hours per year. Claim incidence rates were calculated as the number of compensable claims per 10,000 FTE. Industry groups with ≥25 compensable workers' compensation claims and ≥100 FTE per year during the study period were selected for further analysis. This was done, in part, to eliminate the possible identification of single employers or claimants. No construction industry groups were excluded based on these criteria. Injury categories, with ≥1,000 compensable claims were chosen. After applying these criteria, six injury categories “fall from elevation,” “fall on same level,” LE-MSD, WMSD, “struck by/against,” and

Table 1
Prevention Index (PI[a]) Ranking by North American Industry Classification System (NAICS) Industry Group[b] for All Washington State Workers' Compensation Compensable Claims, 2003-2007.

Industry	Severity[c]	Count	Count Rank	Claim Rate[d]	Rate Rank	PI	PI Rank
2381 Foundation, Structure, and Building Exterior Contractors	125587	9008	1	671	7	4	1
4841 General Freight Trucking	105368	3048	8	590	9	8.5	2
2361 Residential Building Construction	92532	5226	3	534	14	8.5	2
2383 Building Finishing Contractors	114413	4342	5	522	15	10	4
1133 Logging	131166	1549	26	944	4	15	5
6222 Psychiatric and Substance Abuse Hospitals	224458	1410	27	975	3	15	5
4842 Specialized Freight Trucking	120244	1697	25	613	8	16.5	7
6232 Residential Mental Retardation, Mental Health and Substance Abuse Facilities	115559	1228	30	856	5	17.5	8
5617 Services to Buildings and Dwellings	68002	4410	4	423	35	19.5	9
2389 Other Specialty Trade Contractors	79210	2528	12	432	33	22.5	10
5621 Waste Collection	90555	842	42	777	6	24	11
3219 Other Wood Product Manufacturing	63428	1319	29	439	28	28.5	12
2373 Highway, Street, and Bridge Construction	92341	1096	32	444	26	29	13
2382 Building Equipment Contractors	47683	5937	2	327	56	29	13
2362 Nonresidential Building Construction	51756	1901	19	361	47	33	15
2371 Utility System Construction	60914	1371	28	323	58	43	24
2379 Other Heavy and Civil Engineering Construction	58492	525	67	343	50	59	31
2372 Land Subdivision	33185	156	167	173	167	167	191

[a] Prevention Index(PI) = (claims count rank + claims frequency rank)/2.
[b] 266 of 317 NAICS industry groups met the study criteria of ≥100 FTE/year and ≥25 claims over the study period. All ten construction industry groups are ranked.
[c] Time loss days per 10,000 FTE.
[d] Claims rate per 10,000 full time equivalent.

"other" remained. Despite having 1,191 compensable claims, the "other" category was ultimately excluded due to the unrelated injury types and lack of prevention potential, leaving five injury categories for analysis and ranking.

The aggregate incurred claims cost and total hours reported for each industry group and injury type combination were used to calculate the average claim cost per hour. Claim costs were not adjusted for inflation over the five years span of data nor were adjustments made to account for differences in prevailing wage for each industry group. The cost per hour was converted to a comparable rank starting at 1.0 by dividing by the lowest cost per hour. The percentage of claims cost attributable to each industry and injury type combination was defined as the claims cost for the specific injury type within each industry divided by the total cost of the five injury types presented for the industry group. The five injury type categories included in the analysis accounted for an average of 82% of claims costs. Construction industry groups were compared with all other industry groups using cost per claim and cost per reported work hours. Cost per claim was defined as the total incurred cost for each industry group divided by the number of claims. Cost per hour was defined as the total incurred cost for each industry group divided by the number of reported work hours.

Claims were then organized by industry group within injury type and ranked according to severity and their prevention potential. The severity rate within each injury type was calculated as the number of days of time loss per 10,000FTE. The potential for prevention within each injury type was determined using a derived prevention index (PI) and has been used to identify high risk industries (Bonauto et al., 2006) and to identify industries at high risk for musculoskeletal disorders (Silverstein, Viikari-Juntura, & Kalat, 2002). The PI is defined as the average of the rank orders of the claim count and the claim incidence rate or PI = (count rank + incidence rank)/2. The PI was selected because it incorporates the number and frequency of claims and provides an uncomplicated ranking system. The PI uses the count and incidence together, which allows for the comparison of industry groups with highly variable numbers of workers and because each factor has equal influence; the PI helps to identify industries that are at higher risk based on either factor independently. A lower PI represents a combination of a higher number and more frequent injury and illness claims. All rankings include only State Fund compensable workers' compensation claims.

3. Results

3.1. All Compensable Construction Industry Claims

There were 32,090 compensable claims in the construction industry in the Washington State Fund workers' compensation program between 2003 and 2007. By comparison, there were 121,153 non-construction compensable claims during the same period. The construction industry accounted for 9.1% of total FTE and construction claims accounted for 21% of all compensable State Fund claims during the study period. The injury claims rate per 10,000 FTE among construction industry groups ranged from 173 for NAICS 2372 Land Subdivision to 671 for NAICS 2381 Foundation, Structure, and Building Exterior Contractors. The average claims rate for all construction industry groups was 413 per 10,000 FTE, while the claims rate for all non-construction industries averaged 235 per 10,000 FTE. The average severity for all construction industry sectors was 76,000 time loss days per 10,000 FTE or more than twice that of non-construction industry sectors with an average of 35,000 per 10,000 FTE.

3.2. Construction Industry Group Rankings among All Industry Groups

Table 1 presents rankings for all 10 NAICS 4-digit construction industry groups among all other industry groups for all injury types. Construction industry groups occupied 7 of the top 15 ranks in terms of PI for all industry groups among all industry sectors in Washington State from 2003-2007. The construction industry groups with the lowest PI ranking or highest potential for prevention were NAICS 2381 Foundation, Structure, and Building Exterior Contractors followed closely by NAICS 2361 Residential Building Construction. These were ranked first and third among all industry groups. A difference not accounted for by their PI ranking was that NAICS 2381 was 35% higher than NAICS 2361 in terms of severity. Also of note was that NAICS 2383 Building Finishing Contractors, ranked fourth, had a severity rate 24% higher than the second ranked NAICS 2361. For comparison, the industry group NAICS 1133 Logging, was ranked fifth by PI. The remaining construction industry groups not ranked among the top 15 were NAICS 2371 Utility System Construction (ranked 24th), NAICS 2379 Other Heavy and Civil Engineering Construction (ranked 31st), and NAICS 2372 Land Subdivision (ranked 191st), out of the 266 industry groups that met the inclusion criteria. Of these three lower ranked construction industry groups, NAICS 2371 and NAICS 2379 had measures of severity approximately 65-70% higher than the average severity among non-construction industry groups. When all industry groups are ranked by severity, construction industry groups NAICS 2381and NAICS 2383 occupy positions five and eight, respectively. Construction industry groups occupied positions three and four of the top five among all industry groups for number of compensable claims. By claims rate, construction industry groups ranked lower, but 9 of the 10 construction industry groups were ranked in the top 25% of all industry groups for highest claims rates. Construction industry groups occupied several of the top average cost per claim positions when compared with all other industry groups. The average cost per claim for all injury types for NAICS 2373 Highway, Street, and Bridge Construction was $55,700 per claim and it ranked fifth among all industry groups. Ranked sixth among all industry groups was NAICS 2371 Utility System Construction with an average claim cost of $54,800. The median cost associated with all construction claims was $42,100, while the median cost for all non-construction claims was $28,600. The cost ratio for construction industry group compared to all other industry groups averaged 1.5 for cost per claim and 3.0 for cost per work hours reported. Construction industry groups were also compared to all other industry groups by most frequent injury type using cost per claim. The median ratio of cost per claim for construction industry groups to all other industry groups ranged from 1.3 for "LE-MSD" injuries to 1.7 for "fall from elevation" injuries.

3.3. Within Construction Industry Group Rankings

Table 2 presents construction industry groups ranked within specific injury types and compared by PI and severity. The industry groups are listed according to NAICS code and the PI listed within each injury type category is relative to all other industry groups. The total number of non-construction industry groups included in the ranking and the average severity for each is shown at the bottom of the table.

Table 3 presents claims cost comparison measures for the 10 NAICS construction industry groups and 5 injury type combinations. The cost per hour ratios showed that WMSD injury types in NAICS 2373 Highway, Street, and Bridge Construction had the highest relative cost per hour. The next highest per hour claims cost were also associated with WMSD injuries for NAICS 2381 and NAICS 2383. Comparing injury types, WMSD injuries were the highest cost per hour for all industry groups. The next most costly injury type, "fall from elevation," had a lower average ratio across industries, but similar to WMSD was highest for NAICS 2381 and 2383 industry groups. The distribution of claims costs across injury types within each construction industry group showed that WMSD injuries were the highest percentage of injury costs for all industry groups. LE-MSD injuries were the lowest percentage of costs for each industry group except NAICS 2382 Building Equipment Contractors. NAICS 2372 Land Subdivision reported claims of only two injury types, of which 80.6%

Table 2
Prevention Index and Severity by North American Industry Classification System (NAICS) Construction Industry Group and Injury Type Category for Washington State Workers' Compensation Compensable Claims, 2003-2007.

Industry	Fall From Elevation		Fall on Same Level		WMSD[c]		LE-MSD[d]		Struck By/Against	
	PI[a]	Severity[b]	PI	Severity	PI	Severity	PI	Severity	PI	Severity
2361 Residential Building Construction	4.0	22178	15.5	6539	16.0	32914	8.0	5146	5.0	12560
2362 Nonresidential Building Construction	9.0	10113	44.5	2582	41.5	22869	27.0	1738	25.0	7162
2371 Utility System Construction	20.75	5696	55.0	5251	51.5	23716	20.75	2620	39.0	11778
2372 Land Subdivision	-[e]	-	-	-	163.25	15670	-	-	126.5	-
2373 Highway, Street, and Bridge Construction	21.5	6616	48.75	6837	40.0	37261	25.0	5215	29.0	3714
2379 Other Heavy and Civil Engineering Construction	37.5	4361	63.25	4327	77.75	23141	-	-	51.0	14648
2381 Foundation, Structure, and Building Exterior Contractors	1.5	25412	6.0	11177	6.5	46371	3.5	5558	3.5	10437
2382 Building Equipment Contractors	10.5	7544	41.0	3038	33.5	19322	8.5	4004	29.0	19581
2383 Building Finishing Contractors	2.0	29535	17.0	9229	15.5	43608	7.0	6176	18.0	5896
2389 Other Specialty Trade Contractors	10.5	8691	29.75	7039	29.5	30371	13.0	4440	13.5	10183
All Other Industry Groups	100[f]	3332[g]	138	4429	225	16755	74	2332	165	6146

[a] Prevention Index(PI) = (claims count rank + claims frequency rank)/2.
[b] Time loss days per 10,000 FTE.
[c] Non-traumatic work-related upper musculoskeletal, neck, and back disorder.
[d] Lower extremity musculoskeletal disorder.
[e] Did not meet ranking inclusion criteria.
[f] Total number of non-construction industry groups ranked.
[g] Average severity for all non-construction industry groups.

of claims cost were for WMSD injuries and 19.4% were for "struck by/against" injuries.

3.3.1. Fall from Elevation

There were nine construction industry groups that met the criteria to be analyzed for "fall from elevation" injuries. Compensable claims in construction ranked first and second and occupied 6 of the top 10 PI spots for "fall from elevation" injury type when compared with all other industry groups. "Fall from elevation" accounted for 4,718 total claims with 30% coming from NAICS 2381 Foundation, Structure, and Building Exterior Contractors. The claims incidence rate average was 59 claims per 10,000 FTE with NAICS 2381 and NAICS 2383 Building Finishing Contractors at nearly twice the average rate for all construction industry groups. The average incident rate of "fall from elevation" injuries was 60 among all construction industry groups compared to an incidence rate of 20 for the same injury type among all industry groups. When ranked by PI, NAICS 2381 and NAICS 2383 ranked first and second, respectively, while NAICS 2383 was 16% higher in terms of severity. The average severity rate for "fall from elevation" was 13,350 days of time loss per 10,000 FTE and was four times the average severity for non-construction falls from elevation. All construction industry groups had a higher than the average severity, ranging 1.3 to 9 times higher than non-construction industry groups for this injury type. Rankings for PI and severity were in close agreement for "fall from elevation" injuries among construction industry groups. "Fall from elevation" consistently ranked second or third highest for percent of total cost within an industry group after WMSDs and "struck by/against" injury types.

3.3.2. Fall on Same Level

There were nine construction industry groups that met the criteria to be analyzed for "fall on same level" injuries. "Fall on same level" construction claims represented 1.5% of total claims for this period and 16% of all claims of this injury type. Construction industry group NAICS 2381 Foundation, Structure, and Building Exterior Contractors was at the top of PI rankings among all other industry groups for "fall on same level" injuries. Only one other construction industry group, NAICS 2361 Residential Building Construction, was in the top 10 among all other industry groups. Within construction industry groups, NAICS 2381 Foundation, Structure, and Building Exterior Contractors was ranked highest for PI. This was followed by NAICS 2361 Residential Building Construction ranked second and NAICS 2383 Building Finishing ranked third. These two industry groups were differentiated by a 41% higher severity rate for NAICS 2383 than for

Table 3
Claim Costs by North American Industry Classification System (NAICS) Construction Industry Group and Injury Type Category for Washington State Workers' Compensation Compensable Claims, 2003-2007.

Industry	Falls From Elevation		Falls On Same Level		WMSD[a]		LE-MSD[b]		Struck By/ Against	
	Cost[c] Ratio	% in Group	Cost Ratio	% in Group	Cost Ratio	% in Group	Cost Ratio	% in Group	Cost Ratio	% in Group
2361 Residential Building Construction	7.8	29.7	2.1	7.9	10.2	38.8	1.8	6.7	4.4	16.8
2362 Nonresidential Building Construction	4.6	23.6	1.1	5.7	9.1	46.5	1.0	4.7	3.8	19.4
2371 Utility System Construction	3.1	13.9	2.3	10.1	8.6	37.9	1.1	4.7	7.6	33.5
2372 Land Subdivision	-[d]	-	-	-	5.3	80.6	-	-	1.3	19.4
2373 Highway, Street, and Bridge Construction	3.6	11.3	3.5	10.8	15.8	49.4	2.0	6.3	7.1	22.1
2379 Other Heavy and Civil Engineering Construction	2.7	14.7	1.6	8.8	9.5	52.5	-	-	4.4	24.1
2381 Foundation, Structure, and Building Exterior Contractors	9.7	26.4	3.9	10.7	14.5	39.5	1.9	5.1	6.7	18.3
2382 Building Equipment Contractors	3.0	19.2	1.1	7.3	7.2	46.7	1.6	10.3	2.5	16.4
2383 Building Finishing Contractors	10.6	31.5	3.2	9.4	14.3	42.4	2.0	5.9	3.6	10.7
2389 Other Specialty Trade Contractors	3.3	14.5	2.6	11.4	10.0	43.9	1.6	7.2	5.3	23.0

[a] Non-traumatic work-related upper musculoskeletal, neck, and back disorder.
[b] Lower extremity musculoskeletal disorder.
[c] Ratio of cost per hour for industry group and injury category to lowest cost per hour for ten groups and five injury types.
[d] Did not meet inclusion criteria.

NAICS 2361. Severity rate also showed that NAICS 2389 Other Specialty Trade Contractors and NAICS 2373 Highway, Street, and Bridge Construction had higher than average severity rates among construction industry groups. "Fall on same level" injuries were consistently low and were elevated relative only to LE-WMSD injuries for cost ratio and percentage of cost within industry groups.

3.3.3. Struck By/Against Injuries

There were 10 construction industry groups that met the criteria to be analyzed for "struck by/against injuries." These construction claims accounted for 4.3% of total claims and 25% of injuries of this type among all industry groups. The average injury incidence rate for "struck by/against injuries" in construction was 84. This was lower than the incidence rate for all injury types among all construction industry groups but higher than the rate for this injury type among all non-construction industry groups. All construction industry groups except NAICS 2372 Land Subdivision exceeded the average incidence rate of non-construction groups for "struck by/against injuries." Construction industry groups NAICS 2381 Foundation, Structure, and Building Exterior Contractors and NAICS 2361 Residential Building Construction were first and second for PI ranking among construction industry groups. The average severity among construction industry groups for this injury type was 1.8 times the average severity of non-construction industry groups. When ranked according to severity, NAICS 2382 Building Equipment Contractors was highest at 19,581. Despite being highest for severity, NAICS 2382 was fourth when ranked by PI. NAICS 2371 Utility System Construction and NAICS 2379 Other Heavy and Civil Engineering Construction occupy the next to lowest positions when ranked by PI, but NAICS 2379 moves up to second and NAICS 2371 moves to fourth when ranked by severity. "Struck by/against" injury types along with "fall from elevation" consistently ranked second or third highest for percent of total cost within an industry group after WMSDs. The two industry groups for which "struck by/against" and "fall from elevation" injuries differed most were NAICS 2371 Utility System Construction, where "struck by/against" injuries had twice the cost ratio and accounted for 20% more of the total cost, and NAICS 2383 Building Finishing Contractors, where "fall from elevation" had three times the cost ratio and accounted for 20% more of the total cost.

3.3.4. Work-related Musculoskeletal Disorders of the Neck, Back, and Upper Extremities

There were 10 construction industry groups that met the criteria to be analyzed for "Non-traumatic neck, upper musculoskeletal, and back (WMSD)" injuries. WMSD injuries in construction industry groups accounted for 6.4% of injury claims among all injury types across all industry groups. Among WMSD injury types, construction claims accounted for 18% of claims among all industry groups. The claims incidence rate for WMSD injuries in construction was 125 per 10,000 FTE compared to 88 for non-construction industry groups. The severity associated with WMSD injuries was 75% higher for construction than non-construction industry groups. The ratios of severity for WMSD injuries to the severity of other construction industry groups averaged 5.0 and ranged from 1.0 to 13.2. The top three industry groups ranked by PI were NAICS 2381 Foundation, Structure, and Building Exterior Contractors; NAICS 2383 Building Finishing Contractors; and NAICS 2361 Residential Building Construction. When ranked by severity, construction industry group NAICS 2373 Highway, Street, and Bridge Construction was in third position compared to position six in PI rank. NAICS 2382 Building Equipment Contractors ranked ninth according to severity but fourth by PI rank. All construction industry groups except NAICS 2372 Land Subdivision exceeded the average claims incidence rate and severity of non-construction industry groups for WMSD injuries. WMSD injuries consistently had the highest cost ratio among industry groups and injury types and were the highest percent of costs for all industry groups. The average cost ratio for WMSDs was 10.5 and they accounted for an average of 48% of costs for all construction industry groups.

3.3.5. Lower Extremity Musculoskeletal Disorders

For LE-MSDs, eight construction industry groups met the inclusion criteria. LE-MSD injuries in construction industry groups accounted for 29% of all LE-MSD injuries. The average incidence rate of LE-MSD injuries within construction industry groups was 23 claims per 10,000 FTE. The incidence rate ratio of LE-MSD claims among construction industry groups to non-construction industry groups was 1.5, and four of the eight construction industry groups had incidence rate ratios greater than 1.5. The ratio of average severity among construction industry groups to that of non-construction groups was 1.9. Within the construction industry, NAICS groups 2381 Foundation, Structure, and Building Exterior Contractors and NAICS 2383 Building Finishing Contractors were ranked first and second by PI. Ranking by severity, NAICS 2383 Building Finishing Contractors was highest. NAICS 2373 Highway, Street, and Bridge Construction ranked third for severity but only seventh when ranked by PI. NAICS 2373 ranked next to last by PI but third by severity. LE-MSD injuries were consistently lowest for cost ratios and percentage of costs within industry groups.

4. Discussion

While some studies have effectively used BLS data to rank industries and occupations using either claims costs or absences from work, our study presents rankings based on several composite indicators and compares within the construction industry and among several non-construction industry groups.

In this study, we found that NAICS 2381 Foundation, Structure, and Building Exterior Contractors was ranked first for PI among all construction industry groups for the five injury types profiled: "fall on same level," "fall from elevation," "struck by/against,", WMSD, and LE-MSD. In addition, the severity measures for NAICS 2381 were higher than average for all injury types. Welch, Haile, Boden, and Hunting (2009) provides similar findings showing that among current roofers, an occupation within NAICS 2381, 37% reported upper body musculoskeletal disorders, 25% reported lower body musculoskeletal disorders, and 37% reported lower back disorders or sciatica. Additionally, 44% of current roofers reported missing work in the two years preceding the survey.

Leigh, Waehrer, Miller, and Keenan (2004) used the 1993 BLS Annual Survey for the United States combined with cost data from the Detailed Claims Information data set, the National Health Interview Survey, the Current Population Survey, and others and ranked industries based on average cost of injuries and illnesses per worker using Standard Industrial Classifications (SIC) codes. Several construction industries ranked high on the list. Analogous construction industry groups were high among all industries when ranked according to average costs using NAICS codes applied to Washington State data. This suggests that the data in this study may be appropriate for comparing or generalizing to nationwide construction industry data.

This study also highlights the high severity of WMSD injury claims across all construction industry groups, especially NAICS 2381 Foundation, Structure, and Building Exterior Contractors and NAICS 2383 Other Specialty Trade Contractors. Of note is that the severity of WMSD injuries averaged five times the severity of the other construction industry groups and eight times the severity of all other industry groups. Another example was that the industry groups ranked last and next to last for PI within the WMSD injury category and had much higher severity related to WMSD than other injury types. In this example, claims for WMSD injury types may not have had a relatively high number or frequency of claims to generate a higher PI ranking but suffered a relatively high number of time loss days compared with other construction industry groups across the same injury type category. This indicates the need for targeting WMSD

prevention initiatives to reduce days away from work even in industry groups not ranked high according to the PI.

Waehrer et al. (2007) analyzed the costs of fatal and non-fatal injuries in the construction industry in 2002 and determined that five construction industries (by Standard Industrial Classification 1987) accounted for over half of the total costs. They were miscellaneous special trade contractors (SIC 179), followed by plumbing, heating and air-conditioning (SIC 171), electrical work (SIC 173), heavy construction except highway (SIC 162), and residential building construction (SIC152), each with over $1 billion in costs. The Washington State data presented here and organized by NAICS industry groups show that 4 of the 10 construction industry groups accounted for 75% of the total claims cost. These were NAICS industry groups 2381 Foundation, Structure, and Building Exterior Contractors (28%); 2382 Building Equipment Contractors (16%); 2383 Building Finishing Contractors (16%); and 2361 Residential Building Construction (15%).

The analysis by Waehrer et al. (2007) also determined that injury types classified (by BLS injury Event Codes) as "fall to a lower level" and "overexertion" were the top two costly injuries in construction. Washington State data showed a similar ranking with WMSD injuries accounting for 43% and "fall from elevation" injuries accounting for 24% of total incurred claims costs. "Struck by/against" injuries also accounted for 18% of total costs. These two injury types also had the highest average cost per hour worked among the five injury types included.

Despite increased documentation and awareness about new fall protection requirements enacted in 2000 in Washington State, "fall from elevation" continues to be a major hazard as shown by the claim associated severity for Foundation, Structure, and Building Exterior Contractors, Building Finishing Contractors, Residential Building Construction, and construction in general compared to the severity among non-construction industries. Additionally, the low PI for "fall from elevation" injuries compared to other injury types.

5. Limitations

These rankings and severity measures were not based on true exposure data and provide little exposure or risk factor information besides industry group and the hours reported. Hours reported were used as a surrogate for exposure and claim costs were expressed on an hourly basis. This may be misleading in the case of salaried employees with assumed hours or workers paid by the piece or amount of material used or finished.

Self insured claims in construction comprised 5.4% of State Fund claims during this period. The exclusion of self insured claims from these data may have influenced the cost estimates and relative rankings presented. The exclusion of self insured data may result in an underestimation of costs and time loss across the construction industry as self-insured employers are not required to report non-paid time loss injuries to L&I.

The use of construction industry groups as broad categories of classification may limit the ability to pinpoint high risk construction occupations and tasks. Also, the Washington State construction industry may differ by common injury types from other states or regions. However, the use of the PI along with the severity and the relative average claims cost across industry groups and injury types provides a basis for prioritizing prevention strategies and for comparison with other states and within the construction industry in the United States.

References

Bureau of Labor Statistics [BLS]. (2008). *Workplace injuries and illnesses in 2007*. Washington, DC: Author.

Bonauto, D., Silverstein, B., Adams, D., & Foley, M. (2006). Prioritizing industries for occupational injury and illness prevention and research, Washington State Workers' compensation claims, 1999-2003. *Journal of Occupational and Environmental Medicine*, *48*(8), 840−851.

Cheadle, A., Franklin, G., Wolfhagen, C., Savarino, J., Liu, P. Y., Salley, C., et al. (1994). Factors influencing the duration of work-related disability: a population-based study of Washington State workers' compensation. *American Journal of Public Health*, *84*(2), 190−196.

Dement, J. M., & Lipscomb, H. (1999). Workers' compensation experience of North Carolina residential construction workers, 1986-1994. *Applied Occupational and Environmental Hygiene*, *14*(2), 97−106.

Entzel, P., Albers, J., & Welch, L. (2007). Best practices for preventing musculoskeletal disorders in masonry: stakeholder perspectives. *Applied Ergonomics*, *38*(5), 557−566.

Glazner, J. E., Borgerding, J., Lowery, J. T., Bondy, J., Mueller, K. L., & Kreiss, K. (1998). Construction injury rates may exceed national estimates: evidence from the construction of Denver International Airport. *American Journal of Industrial Medicine*, *34*(2), 105−112.

Horwitz, I. B., & McCall, B. P. (2004). Disabling and fatal occupational claim rates, risks, and costs in the Oregon construction industry 1990-1997. *Journal of Occupational and Environmental Hygiene*, *1*(10), 688−698.

Leigh, J. P., & Miller, T. R. (1998). Job-related diseases and occupations within a large workers' compensation data set. *American Journal of Industrial Medicine*, *33*(3), 197−211.

Leigh, J. P., Waehrer, G., Miller, T. R., & Keenan, C. (2004). Costs of occupational injury and illness across industries. *Scandinavian Journal of Work, Environment & Health*, *30*(3), 199−205.

North American Industry Classification System [NAICS] (2002). *North American Industrial Classification System*. Washington, DC: Author.

Silverstein, B., Viikari-Juntura, E., & Kalat, J. (2002). Use of a prevention index to identify industries at high risk for work-related musculoskeletal disorders of the neck, back, and upper extremity in Washington state, 1990-1998. *American Journal of Industrial Medicine*, *41*(3), 149−169.

Silverstein, B., Welp, E., Nelson, N., & Kalat, J. (1998). Claims incidence of work-related disorders of the upper extremities: Washington state, 1987 through 1995. *American Journal of Public Health*, *88*(12), 1827−1833.

Waehrer, G. M., Dong, X. S., Miller, T., Haile, E., & Men, Y. (2007). Costs of occupational injuries in construction in the United States. *Accident; Analysis and Prevention*, *39*(6), 1258−1266.

Welch, L., Haile, E., Boden, L. I., & Hunting, K. L. (2009). Musculoskeletal disorders among construction roofers–physical function and disability. *Scandinavian Journal of Work, Environment & Health*, *35*(1), 56−63.

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